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THE DYNAMIC INFORMATION ARCHITECTURE SYSTEM: AN ADVANCED SIMULATION FRAMEWORK FOR MILITARY AND CIVILIAN APPLICATIONS

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ABSTRACT

DIAS, the Dynamic Information Architecture System, is an object-oriented simulation system that was designed to provide an integrating framework in which new or legacy software applications can operate in a context-driven frame of reference. DIAS provides a flexible and extensible mechanism to allow disparate, and mixed language, software applications to interoperate. DIAS captures the dynamic interplay between different processes or phenomena in the same frame of reference. Finally, DIAS accommodates a broad range of analysis contexts, with widely varying spatial and temporal resolutions and fidelity.

INTRODUCTION

As the power of computers has increased and the cost of hardware decreased, the use of the computer as a tool in complex problem solving has become routine. Problems that were once considered solvable only by large supercomputers can now be addressed using desktop and smaller networked platforms.

With the power of the hardware increasing at a dramatic pace the need has also existed for software frameworks that would permit the user to integrate different models and applications in a dynamic fashion. The Dynamic Information Architecture System (DIAS) was developed by the Argonne National Laboratory to provide just such a framework.

DIAS is an object-oriented system that integrates new or legacy models and applications in a dynamic framework that is driven by the context of the problem being addressed. That is, DIAS can reason on the context of the problem and select the proper models, applications, and databases required to solve the problem.

DIAS has been under development since 1994 and used in a number of applications in both the DoD and civilian sectors. Development begin with support from the Department of Energy and the J-8 Directorate of the Joint Chiefs (JCS/J-8). Continued support for basic architectural development was provided by the Defense Modeling and Simulation Office (DMSO).

DIAS is being used in three significant implementations. Figure 1 shows the users and sponsors of DIAS in its different instantiations. In addition to the three specific instantiations of DIAS, DIAS technology was used by the US Air Force in their theater level mesoscale weather forecast model and in the development of the Joint Warfare Analysis System (JWARS) that is being developed for the Joint analytic community.

The first use of DIAS was as the Dynamic Environmental Effects Model (DEEM). DEEM was used to provide environmental representation and effects modeling for JCS/J-8 and the JWARS Program. In addition, DEEM has also been used as a framework for hydrologic modeling by the US Army Corps of Engineers and the South Florida Water Management District.

The second instantiation of DIAS is in the Distributed Intelligent Agents for Logistics (DIAL) program. The DIAL program involves the integration of legacy logistics models with intelligent agents in order to monitor the flow of personnel and materiel, to identify problems in the logistics network, and to suggest solutions to them. In the DIAL application, a number of models and intelligent agents (developed by the Pennsylvania State University) were integrated via DIAS. The models and agents were developed in a variety of a languages and the resulting system operates in a distributed fashion.

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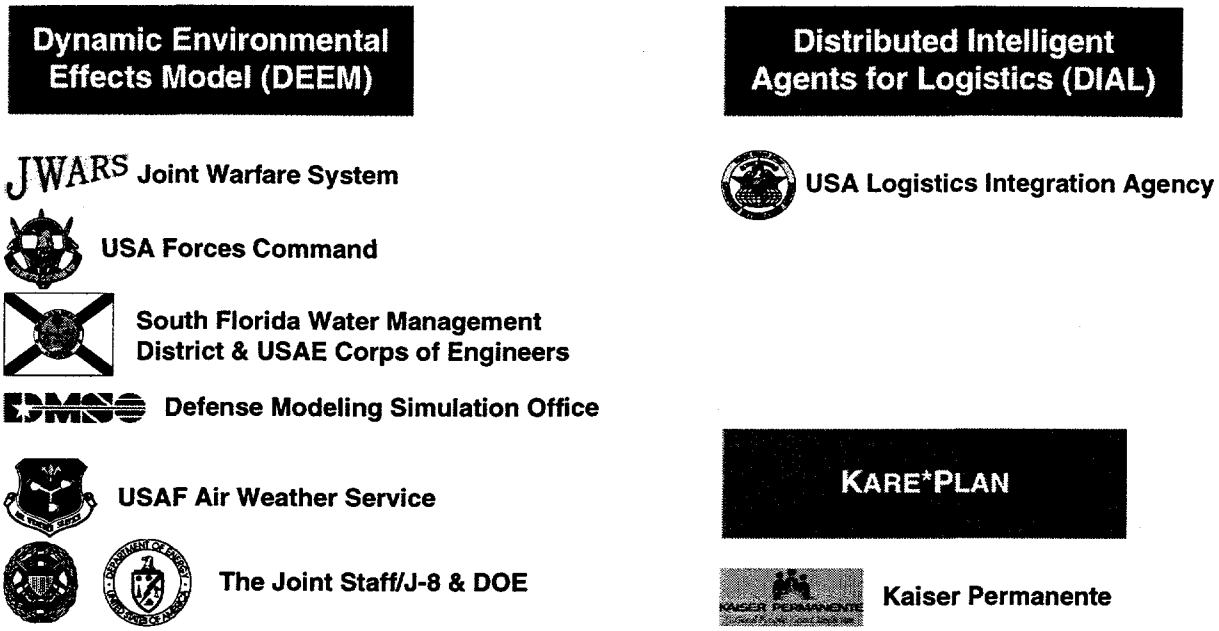

Figure 1. Users and Sponsors of the Dynamic Information Architecture System.

The third instantiation of DIAS is as KARE*PLAN, an end-to-end simulation of the health care system of a private sector health care provider. Members make appointments for visits, interact with the health care organizations and individual providers who then make diagnoses and prescribe treatment plans. The illness or medical conditions evolve with time and respond to treatments and procedures. The use and scheduling of personnel and material resources required to interact with and treat patients are also accounted for in KARE*PLAN.

DESCRIPTION OF DIAS

Figure 2 gives a schematic representation of how DIAS operates. The representation shown in Figure 2 is for the DEEM implementation used to provide environmental representation for the JWARS prototype development effort.

DIAS operates in a mixed language environment. The core DIAS components have been developed using Smalltalk and augmented with C and C++ when performance is an issue. The models and applications that are integrated with DIAS are integrated "as is" in whatever programming language there were developed in.

DIAS is a frame based object-oriented system developed upon the concept of Entity objects as analogs to the "real world" entities that make up the problem. An extensive library of entity objects has been developed that can be used in modeling environmental, transportation, and command and control applications. DIAS also includes a general Course of Action (COA) generation capability. Figure 3 shows the Entity object hierarchy that has been developed for the DEEM instantiation of DIAS.

A DIAS simulation is begun by implementing a suitable conceptual frame which will contain all of the entities being used in the specific problem being addressed. If the problem involves spatial dimensions, as in the DEEM applications, georeferencing and any emphemris requirements are automatically established during the implementing of the frame.

A Frame Toolkit provides utilities for building and instantiating the required Entity objects and ingesting data from external sources. In the example shown in Figure 2, the data are being provided by the Master Environmental Library (MEL) and the National Imagery and Mapping Agency (NIMA).

The context of the problem is captured in a Context object that is used by the DIAS Artificial Intelligence-based Context Manager to match the goals and constraints of the user to the models, applications, and databases integrated into DIAS. The user can let the Context Manager make the selection of simulation resources or the user can specify the resources.

Entity objects can have a number of behaviors that are represented by an Aspect object that is the notional expression of the behavior. The specific implementation of the behavior (*i.e.* model, algorithm, data source, etc.) is described with a Process object. These can be provided by external models or applications, such as those shown in Figure 2.

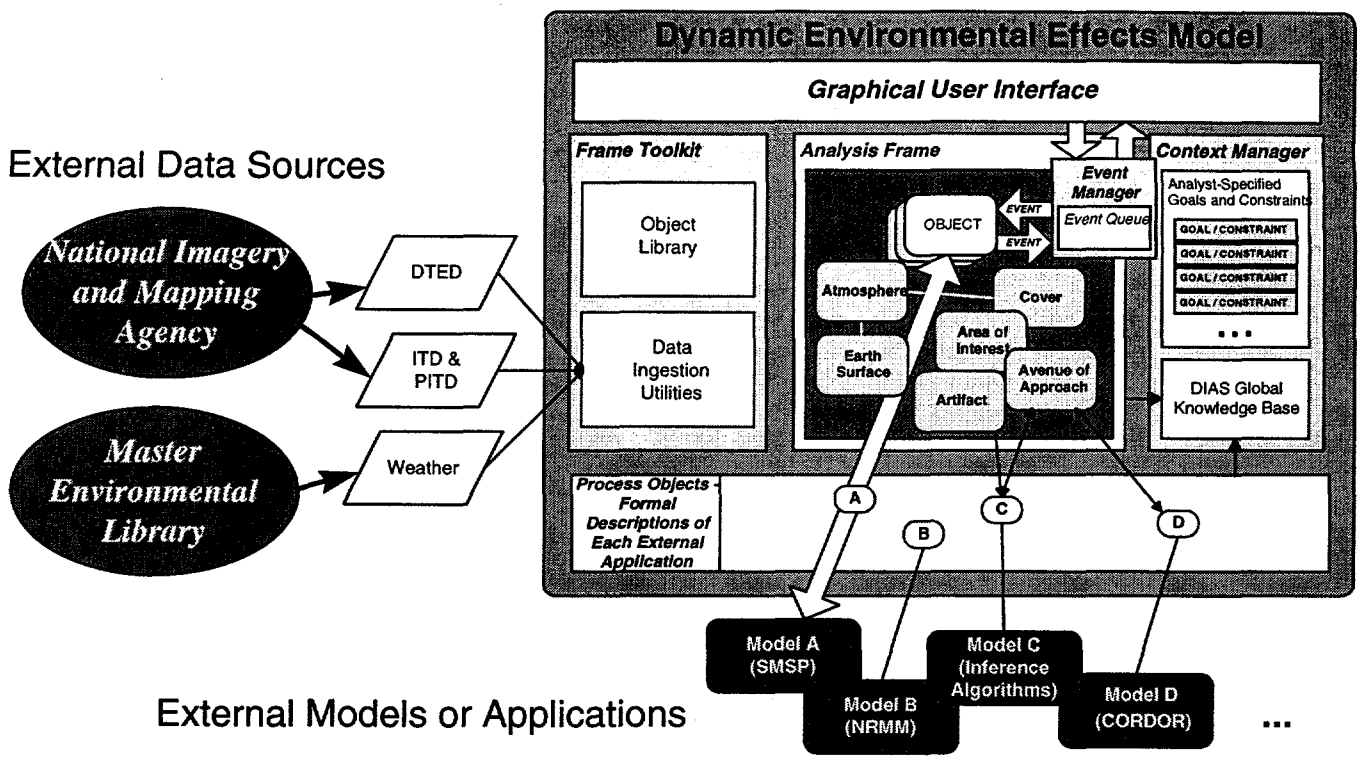

Figure 2. Schematic Representation of the DEEM Instantiation of DIAS Used to Provide Environmental Representation for the Joint Warfare Analysis Prototype Development Effort.

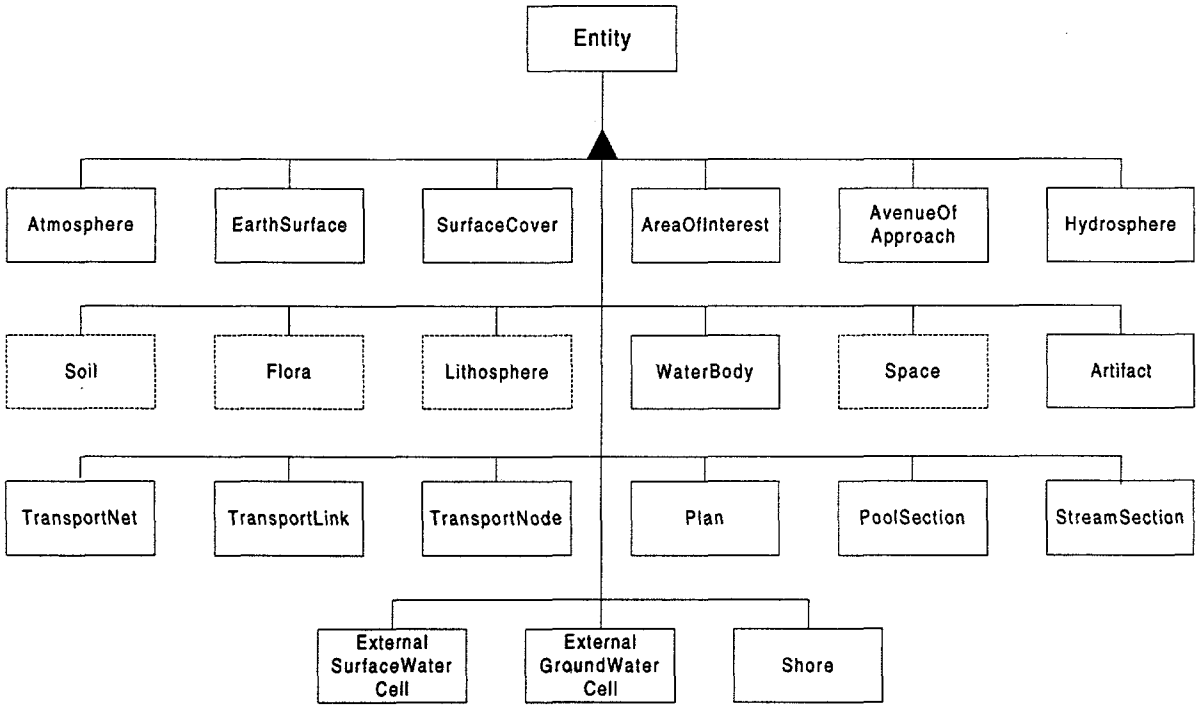

Figure 3. Entity Object Hierarchy Developed for the DEEM Instantiation of DIAS. Objects is Solid Boxes Have Been Developed and Implemented and Objects in Dashed Boxes Have Been Designed and are Awaiting Implementation.

The models and applications used in a DIAS instantiation are typically external to the DIAS software and can be distributed across a network of processors or can be run on a parallel distributed memory computer. DIAS can be readily made compatible DMSO High Level Architecture federations.

The implementation of DEEM led to the development of an object oriented spatial display tool called the GeoViewer, which can be dynamiclly linked to the objects with a DIAS simulation. The GeoViewer is used to display, analyze, manipulate, and intelligently query spatial data and objects used in a DIAS simulation.

Figure 4 gives two examples of spatial displays available from the GeoViewer. The GeoViewer can ingest data from sources, such as Digital Terrain Elevation Data, Interim Terrain Data, Planning Interim Terrain Data, Vector Interim Terrain Data from NIMA; TIGER data, from the Department of the Interior; soils data from the US Geological Survey; and meteorological data from MEL.

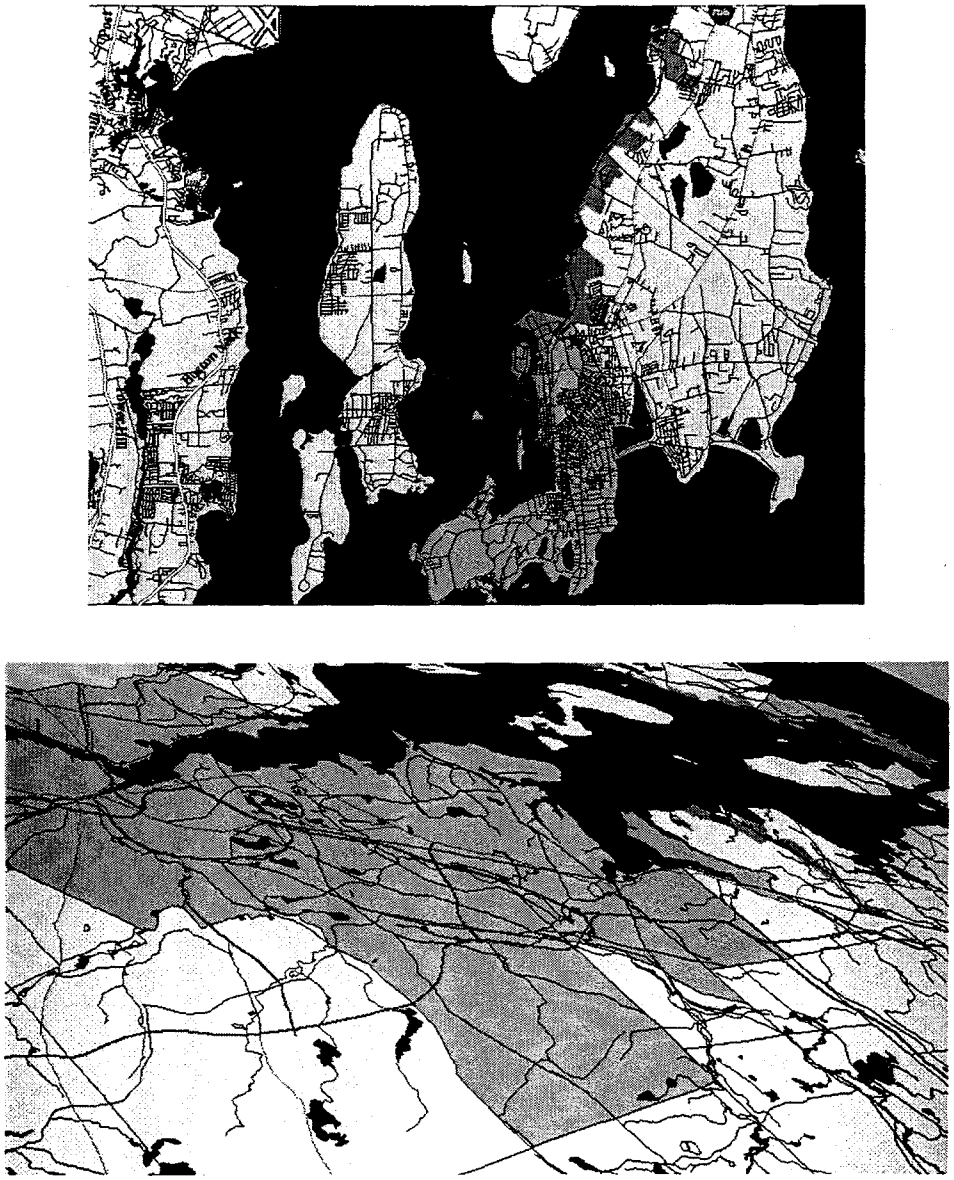

Figure 4. Two Perspectives of the Newport, Rhode Island Area, Based on TIGER Data, Displayed Using the Argonne GeoViewer. TIGER The Upper View is a Straight Down View of the Newport, Rhode Island Area While the Lower View is a Perspective View Looking From the Southwest.

EXAMPLES OF DIAS APPLICATIONS

Providing Environmental Representation and Effects

The DEEM instantiation of DIAS was used to provide the environmental representation and effects for the JWARS prototype development effort. JWARS is intended as the analysis model for the Joint analytic community and will require a detailed representation of the environment and those factors that can impact military operations.

DEEM provided environmental representation in the JWARS study area of Bosnia. A gridded representation of the land and air environments was provided along with a simple ocean representation. (DEEM also included environmental representation for road, rail, and air transportation networks but they were not used during the prototype development effort.)

Environmental data were provided over a thirty day period using weather data provided by MEL. These data were used to provide precipitation data that impacted the soil moisture conditions in the study area. The soil moisture state was then calculated and used in the calculation of maximum vehicle speeds that could be achieved by different vehicle types over the study area. From these results, mobility corridors are calculated for different unit configurations. The Analyst then graphically creates avenues of approach and named areas of interest, as shown in Figure 5, using tools based on the GeoViewer. These can be created for both Red and Blue forces. The final set of avenues of approach are stored as objects and used by JWARS in the interactions and engagements between the forces during the course of the simulation.

Course of Action Modeling

In developing KARE*PLAN, the need existed to be able to model the development of Courses of Action (COA) for the diagnosis and treatment of different medical phenomena. What came out of that effort was the development of a general application for developing courses of action that could be used for both military and civilian applications.

The key elements of our COA application are the ability to model as objects the participants (*e.g.* people, organizations, facilities) involved in the determination of a COA; capturing the data or information required for the analysis of a COA; tracking the resources, including time, required to generate a COA; and the use of a step template that is able to incorporate all aspects of the task(s) required to accomplish a COA. Individual tasks can be broken down into subtasks that can themselves be the result of a COA generation process.

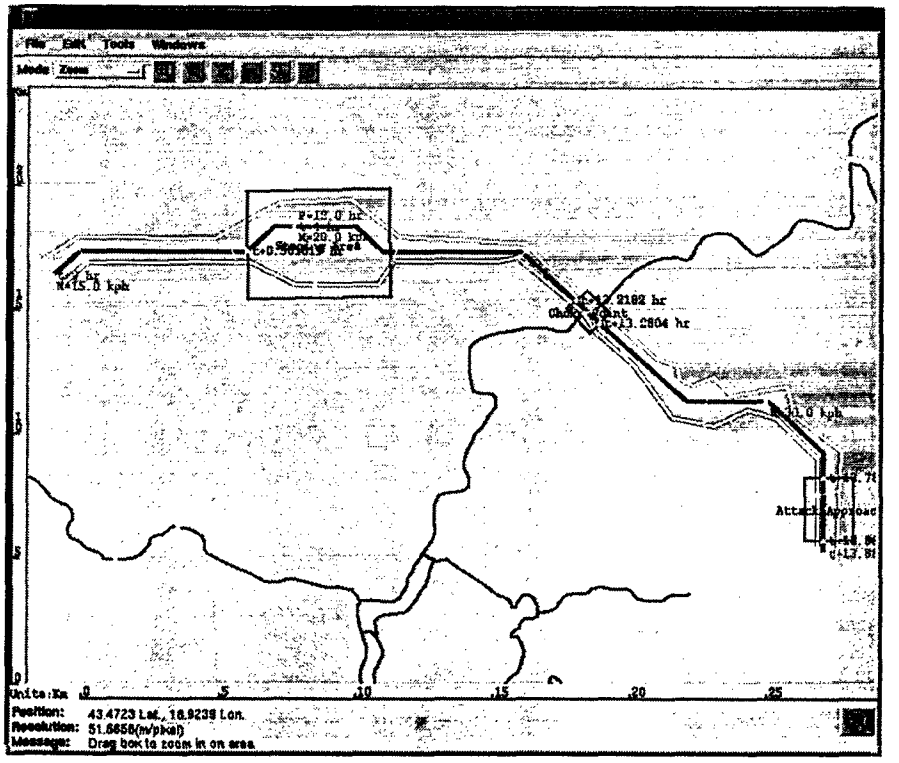

Figure 5. Avenues of Approach and Named Areas of Interest Graphically Developed Using Argonne's GeoViewer and Used by JWARS in the Simulation of Interactions Between Blue and Red Forces.

The COA generator is being used extensively in the KARE*PLAN program but is also being proposed for use in other applications. For example, the generalized nature of the approach makes it attractive for use in the modeling of any command and control application. Specific applications that have been proposed include modeling for Operations Other Than War and the generation of weather forecast products in analysis applications.

SUMMARY

Computer simulations are an important part of problem solving in the defense and civilian sectors and involves the extensive use of new and legacy software. The Dynamic Information Architecture System was developed to provide a powerful and flexible simulation framework in order to integrate new and legacy models and applications for use in a dynamic, context driven-frame of reference.

DIAS is a fully object-oriented system that uses the context of a problem to identify the proper models, applications, and databases to use to solve a given problem. DIAS has been and is continuing to be used by a number of sponsors in the DoD and civilian communities on an array of complex problems ranging from environmental representation and effects to the integration of legacy logistics applications to the end-to-end simulation of health care.

ACKNOWLEDGEMENT

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